CHAPTER III.4. COST OF LIMB REDUCTIONS

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CHAPTER III.4. COST OF LIMB REDUCTIONS

III.4.A Background

This chapter contains a discussion of the methods used and the results of estimating the direct medical costs incurred by individuals with limb reductions, and the results of the analysis.[1] It does not include information on elements such as indirect medical costs, pain and suffering, lost time of unpaid caregivers, etc. The reader is referred to Chapter I.1 for a discussion of the cost estimation methods and cost elements that are relevant to all benefits estimates. In addition, Chapter III.1 contains information regarding the special characteristics of developmental defects, and a list of chemicals that may cause developmental abnormalities.

The costs presented in this chapter were current in the year the chapter was written. They can be updated using inflation factors accessible by clicking on the sidebar at left.

Link to Chapters I.1 and III.1
Link to inflation factors

III.4.A.1 Description

Limb reductions are the partial (meromelia) or complete (amelia) absence of arms or legs. They vary with respect to the bones, muscles, and other structures affected.

III.4.A.2 Concurrent Effects

Children with limb reductions frequently have other birth defects. In 30 to 53 percent of affected children, other malformations are present, including anomalies of the heart, kidney, anus, abdominal walls, esophagus, vertebrae, and palate. Webbing between digits and spina bifida are also associated with this defect (Waitzman et al., 1996).

III.4.A.3 Causality

Table III.1-1 in Chapter III.1 lists numerous chemicals associated with developmental abnormalities in human and/or animal studies. Many of these chemicals have caused structural and anatomical defects. Limb reductions fall into this category of defects.

Link to Table III.1-1 in Chapter III.1

[1] "Costs" in this chapter refer to direct incremental per capita medical costs, unless otherwise noted.

A recently completed study of the offspring of pesticide application workers found that their incidence of skeletal anomalies, which includes limb reductions, was significantly greater than that of the general population in the same area of the United States (Garry et al., 1996). Respiratory system, circulatory system, and urogenital anomalies also occurred at increased rates. Musculoskeletal anomalies include any abnormality in the size, shape, or function of part of the skeletal system, muscles, and related tissues (e.g., cartilage). They include the absence or shortening of limbs (as discussed in this chapter) and the abnormal formation of part of the skeleton or related soft tissue and cartilage, (as discussed in Chapter III.3). The chemicals evaluated in the study that were associated with the birth defects were trifluralin, triazine herbicides (including atrazine, a very common well contaminant in agricultural areas), and chlorophenoxy herbicides (including MCPA and 2,4-D, a pesticide with very high usage). There was also a significant increase in birth defects among infants conceived in the spring (i.e., during peak chlorophenoxy use) compared to infants conceived during other periods of the year (Garry et al., 1996). As indicated in the introductory developmental effects chapter (III.1), the timing of exposure is often a critical determinant of whether and what type of effects will occur.

Links to Chapters III.3 and III.1

Generally, the earlier during a pregnancy that damage occurs, the more serious the effect will be, because all cells developing from the damaged cells may also be damaged or eliminated, and basic structures are being formed during the first trimester (three months). Although Garry et al. (1996) does not provide detailed information on the nature of the skeletal and other anomalies, information can be obtained from the author or from EPA (which funded the work).

III.4.A.4 Treatment and Services

Individuals with limb reductions are treated using a variety of surgical techniques, are fitted with prostheses, and usually require physical and/or occupational therapy (Mason, 1991). Limb reductions may occur at any point from the joint which attaches the limb to the body (i.e., shoulder or hip) to the distal point of that limb, and may affect some or all of the bones, muscles, cartilage, and other structures comprising the limbs. The structures involved and the types of surgical approaches used are too diverse and numerous to describe in this chapter. Depending on the nature of the limb reduction, this type of birth defect may require multiple complex surgical corrections. Following the initial surgical and related treatments, prostheses are usually replaced each year up to five years. They are replaced biennially after that, up to twelve years, and every two to five years after that (Waitzman et al., 1996).

III.4.A.5 Prognosis

Twelve to twenty percent of infants with limb reductions die during infancy, primarily due to other anomalies (as noted above) (Froster-Iskenius and Baird, 1990). Individuals with limb reductions who have received appropriate medical treatment usually have good functional capabilities (in the absence of other unrelated serious medical problems), although their physical actions may be slowed by their disabilities. There are significant psychosocial implications of these permanent disabilities; these may require medical or other treatment (Waitzman et al., 1996).

III.4.B Costs of Treatment and Services

III.4.B.1 Methodology

Chapters III.3 through III.8 of this handbook use cost of illness estimates developed primarily by Waitzman et al. (1996). Waitzman et al. used the same methodology to estimate the costs incurred by individuals with limb reductions as for all the birth defects for which they estimated costs. The methodology and relevant considerations are detailed in Chapter III.3, including discussions of direct and indirect costs, prevalence versus incidence, incremental costs, and concurrent effects. The analytic method, the sources of data, and the limitations of the Waitzman et al. method are also discussed in Chapter III.3. The methodology is outlined briefly here.

Link to Chapter III.3.

To estimate the lifetime medical costs incurred by an individual with a birth defect, Waitzman et al. estimated the average lifetime medical costs for an individual with the birth defect. From this value, the authors subtracted the average lifetime medical costs for an individual without the birth defect. This yielded the incremental costs associated with the birth defect. Because they estimated lifetime costs, they used an incidence-based approach. Ideally, they would have tracked the costs of the cohort members over time, until the death of the last cohort member. Because the members of the cohort were born in 1988, however, this tracking was not possible. Instead, estimates of the costs incurred at each age were based on estimates of per capita costs in the prevalent population of that age (see Chapter III.3, Section III.3.B.1.2).

Link to Chapter III.3, Section III.3.B.1.2

This method has two important implications. First, Waitzman et al. estimated the costs incurred by individuals with birth defects, including all medical costs incurred, rather than the cost of the birth defect per se.

These cost estimates therefore include the costs of concurrent effects (unlike the costs reported for many of the diseases in this handbook). This method yields a more comprehensive assessment of total costs than would be obtained if only individual effects were evaluated. This method is of particular use in valuing the avoidance of birth defects because they very frequently occur in clusters within an individual. As Waitzman et al. note, however, the costs of associated anomalies are included as part of the estimate of the costs incurred by an individual with a given birth defect. These cost estimates therefore cannot be aggregated across birth defects because of the possibility of double counting.

Second, the Waitzman et al. method estimates the *incremental* costs for individuals with birth defects — that is, the costs above and beyond the average costs that would be incurred by individuals without the birth defect.

Waitzman et al. (1996) estimated three categories of costs incurred by individuals with limb reductions: direct medical costs, direct nonmedical costs, and indirect costs.[2] Direct medical costs, specifically inpatient care, outpatient care, pharmaceuticals, laboratory tests, X-rays, appliances, and long-term care are included in the cost estimates shown in this and other chapters (Chapters III.3 through III.8) based on the work of Waitzman et al. Nonmedical direct costs, specifically developmental services, and special education are also included in this handbook.

The Waitzman estimates of the costs incurred by individuals with limb reductions are based on the costs of this birth defect in California across many ages, and its occurrence in a large cohort of children born in California in 1988. California's ongoing birth defects monitoring program provides an excellent source of data. The California data sets were linked with other national data sets so that Waitzman et al. could estimate the incremental costs associated with limb reductions.

The method of calculating the expected lifetime incremental costs for an individual with a birth defect — i.e., the average lifetime cost per case — is the same for all the birth defects considered by Waitzman et al. The expected per capita cost at age *i*, PCC_i, for an individual born with the birth defect is the probability of surviving to age *i* (among those individuals born with the birth defect), ps_i, times the per capita cost among individuals who do survive to age *i* ($PCPREV_i$, measured in the prevalent population):

$$PCC_i = (ps_i) \times (PCPREV_i) .$$

[2] Indirect costs are not generally discussed in this handbook and so are not included in this chapter. The reader may wish to consult Waitzman et al. (1996) for information on these costs.

Waitzman et al. estimate per capita costs in the prevalent population of age *i*, $PCPREV_i$, in two different ways, depending on data availability (see Chapter III.3).

Link to Chapter III.3

The present discounted value of expected per capita lifetime costs of the birth defect, PCCOBD, is just the sum of these expected age-specific per capita costs, appropriately discounted (as explained more fully in Chapter III.3):

$$PCCOBD = \sum_i PCC_i/(1+r)^i .$$

III.4.B.2 Results

Waitzman et al. (1996) estimate the medical costs of two different groups of limb reductions: upper limb reductions and lower limb reductions. The following tables outline the various costs associated with both types. They are updated from 1988 to 1996 dollars based on the medical care cost component of the Consumer Price Index (1996:1988=1.6465).

Table III.4-1 shows annual per capita medical costs incurred by individuals with limb reductions by age group. Upper limb reductions tend to be correctable at birth, and thus the costs decrease over time. The costs of lower limb reductions, on the other hand, tend to increase with time beyond the initial cash outlay, because lower limb reductions are less correctable and require ongoing medical services.

Table III.4-1: Annual Per-Capita Medical Costs of Limb Reductions by Age Group (1996$)

Condition	Age 0-1	Age 2-4	Age 5-17	Age 18+
Upper Limb Reduction	$8,985	$659	$456	$280
Lower Limb Reduction	$11,888	$1,215	$1,786	$3,492

The medical cost of the average population was then subtracted from these costs to obtain incremental costs. Waitzman et al. (1996) discounted these costs using three different discount rates: two percent, five percent, and ten percent. Although these discount rates do not match the standard EPA rates used in many other chapters in this handbook (zero percent, three percent, five percent, and seven percent), there is insufficient information provided in Waitzman et al. (1996) to allow a conversion to discounted costs using standard EPA discount rates. This problem exists in all chapters based on the Waitzman et al. data (i.e., Chapters III.3 through III.8).

The present discounted values of average per capita lifetime incremental costs, using discount rates of two percent, five percent, and seven percent, are listed in Table III.4-2 below. Direct medical costs and direct non-medical costs are listed separately. The sum of per-capita direct medical and nonmedical costs provides an estimate of the total per-capita costs incurred by individuals with limb reductions.

Table III.4-2: Per-Capita Net Medical Costs, Nonmedical Costs, and Total Costs of Limb Reductions (1996$)

Cost Element	2%	5%	10%
Upper Limb Reduction			
Net medical costs	$8,232	$8,232	$8,232
Net nonmedical costs	$28,372	$21,574	$14,342
Total costs	$36,604	$29,806	$22,574
Lower Limb Reduction			
Net medical costs	$39,515	$26,343	$18,111
Net nonmedical costs	$28,332	$21,537	$14,311
Total costs	$67,847	$47,880	$32,422

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Link to inflation factors

The costs associated with lower limb reductions are significantly higher than those associated with upper limb reductions. This difference is due to the weight bearing issues associated with lower limb reductions that require more extensive surgical therapy. Because the legs are necessary for proper balance, lower limb reductions often produce more complications, and thus require more surgery than reductions in the arms.